Hyperthermia during occipito-cervical fusion with acrylic cement

Epidural thermometry in 23 cases

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In 22 patients, 23 posterior occipito-cervical fusions using acrylic cement were studied; 18 had seropositive rheumatoid arthritis and 4 traumatic atlanto-axial instability. The mean age was 60 (39–75) years. During the curing of the cement, epidural temperature measurements were performed over the cerebellum and between the foramen magnum and C1. Temperatures up to 69 °C were recorded. Cooling with profuse surface irrigation using normal saline solution or precooled 8 °C fluid did not influence the maximal temperatures recorded under the cement. Even though no gross neurological damage was noted, the epidural temperatures in occipito-cervical fusion with acrylic cement can be of sufficient degree to be hazardous; surface irrigation does not seem to be an effective way to reduce this risk.

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Few reports have focused on the effect of curing of acrylic cement on nervous tissues (Scoville et al. 1967, Yokota et al. 1982). For a 30-minute heating period, approximately 44 °C has been suggested as the highest temperature tolerable to the spinal cord (Uchiyama et al. 1989). In the rabbit the threshold temperature for impaired bone regeneration is in the range of 44–47 °C (Eriksson and Albrektsson 1983).

We analyzed whether the temperature elevation during the curing of acrylic cement in occipito-cervical fusion could be a hazard and whether irrigation with fluid could be an effective counteracting measure.

Patients and methods

A series of 22 patients (16 women), 18 with seropositive rheumatoid arthritis and 4 with traumatic atlanto-axial instability, all subjected to posterior occipito-cervical fusion using acrylic cement, were studied (Table 1). One patient was reoperated, and the second fusion was also included in the study. The mean age was 60 (39–75) years. All patients with rheumatoid arthritis complained of occipital headache and/or neck pain prior to surgery. 6 of them also had signs of myelopathy. The 4 patients with traumatic instability had a fracture of the odontoid with nonunion and complained of neck pain but had no signs of myelopathy. The patients were followed clinically for 21 (6–30) months.

Operative technique

The fusion consisted of extradural wiring of the occipital bone to C2 with sublaminar wiring of C1, encasement with acrylic cement and bone grafting. For wiring, the occipital bone was trephined with four burrholes, 10 mm in diameter, two on each side of the midline (Brattström and Granholm 1976, Zygmunt et al. 1988a, 1988b).

One patient (Case 22) was also subjected to laminectomy because of posterior compression at the C1–C2 level; in another patient (Case 18) the posterior arch of C1 fractured during the wiring and therefore a laminectomy was performed.

30–40 g of Palacos® cum Gentamicin (Schering Corp, U.S.A.) was precooled (8 °C) and placed on one side of the midline. The bone graft was placed on the opposite side. With this technique, the cement is in direct contact with the cerebellar dura in the occipital burrholes and the medullary dura between the foramen magnum and the cervical laminae.

Irrigation

No surface irrigation of the cement was performed during the procedure in 7 cases. Profuse surface irriga-

Table 1. Clinical data and epidural temperatures in 23 cases of occipito-cervical fusion

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
No irrigation																			
1	F	63	RA	++	–	–	–	46	–	37	9.1	–	–	3.2	–	–	–	–	–
2	F	47	RA	++	–	–	–	48	47	39	14.0	10.2	–	5.2	3.0	–	1.0	1.0	–
3	M	56	RA	++	–	–	–	39	47	–	–	5.2	–	–	1.5	–	–	–	–
4	F	50	RA	++	+	–	–	48	49	40	12.2	15.4	–	4.2	8.4	–	2.1	4.4	–
5	M	57	RA	++	–	–	–	44	49	38	12.1	14.0	–	–	6.1	–	–	2.5	–
6	M	43	Odontoid fract.	++	–	–	–	53	42	36	17.3	4.2	–	8.4	–	–	4.0	–	–
7	F	63	RA	++	+	–	–	45	50	37	14.4	20.2	–	4.4	11.1	–	–	7.0	–
Irrigation with fluid at approx. 20 °C																			
8	F	62	RA	++	–	–	–	45	45	–	10.2	7.4	–	3.0	2.0	–	–	–	–
9	F	73	RA	++	+	–	–	49	47	–	10.0	11.0	–	6.2	6.2	–	4.0	1.4	–
10	F	58	Odontoid fract.	++	–	–	–	49	59	–	8.2	14.0	–	4.0	8.2	–	1.5	6.3	–
11	M	45	RA	++	–	–	–	40	–	37	–	–	–	–	–	–	–	–	–
12	F	75	Odontoid fract.	++	–	–	–	35	47	32	–	9.5	–	–	4.2	–	–	–	–
13	F	39	RA	++	–	+	–	41	61	37	–	19.5	–	–	10.1	–	–	7.0	–
14	F	68	RA	++	–	–	–	45	51	31	8.2	9.5	–	3.2	5.2	–	–	3.1	–
15[a]	M	60	RA	++	+	+	–	51	44	35	14.5	9.4	–	6.4	–	–	3.0	–	–
16	F	71	RA	++	–	–	–	44	49	39	13.0	15.3	–	–	9.5	–	–	5.0	–
17	F	73	Odontoid fract.	++	–	–	–	36	49	41	–	13.3	1.4	–	6.2	–	–	3.2	–
Irrigation with fluid at approx. 8 °C																			
18[a]	M	60	RA	++	+	+	–	44	45	22	4.4	6.4	–	–	2.3	–	–	–	–
19	F	60	RA	++	–	+	–	48	–	33	8.1	–	–	4.2	–	–	1.1	–	–
20	F	65	RA	++	–	–	–	45	69	36	9.2	12.2	–	2.4	7.4	–	–	5.5	–
21	F	57	RA	++	–	–	–	41	52	36	4.3	9.0	–	–	5.3	–	–	3.4	–
22	F	59	RA	++	–	++	+	41	30	29	1.0	–	–	–	–	–	–	–	–
23	M	71	RA	++	–	+	–	–	52	–	–	9.0	–	–	5.3	–	–	3.4	–

[a] Cases 15 and 18 are the same patient, the first fusion operation is indicated as Case 15 and the reoperation as Case 18.

A Case number
B Sex
C Age
D Diagnosis
E Preoperative neck pain[b]
F Postoperative neck pain[b]
G Preoperative myelopathy[c]
H Postoperative myelopathy
Maximal temperature
I T1
J T2
K T3

Time in minutes > 40 °C
L T1
M T2
N T3
Time in minutes > 44 °C
O T1
P T2
Q T3
Time in minutes > 47 °C
R T1
S T2
T T3

[b] 4-graded subjective scale
– no pain
\+ moderate
++ severe
+++ disabling complaints

[c] 4-graded objective scale
– no signs of myelopathy
\+ paresthesias and/or numbness and slight limb weakness
++ pronounced weakness
+++ severe quadriparesis

tion with normal saline solution was performed in 16 cases, 10 of them with a solution stored at a temperature of approximately 20 °C and the remaining 6 with precooled fluid stored at a temperature of approximately 8 °C. Continuous irrigation was performed so that the acrylic mass was completely immersed in the fluid during the cooling procedure.

Temperature measurements

The temperature measurements were performed using thermocouples type copper-constantan (Exacon CN 7, Exacon scientific instruments Aps, Roskilde, Denmark), connected to a pen recorder (BBC SE 460, Brown Boveri Goerz Metrawatt, Wien, Austria) with a temperature measuring range of 0–100 °C (accuracy: ± 1 °C). Prior to the encasement with the cement, 3 thermocouples were positioned in the epidural space under visual control (Figure 1). On the cement side one of the thermocouples was positioned to the lower occipital burrhole and one between the foramen magnum and C1. The third thermocouple was positioned to the lower occipital burrhole on the noncemented side.

The temperature measurements were started prior to the cementation and continued until the temperature had dropped below 40 °C (Figure 2, Table 1). In 8 cases, one or two of the three measurements were not obtained because of technical problems.

The Kruskal-Wallis test was used for statistical analysis.

Clinical outcome

All the patients improved; none developed new signs

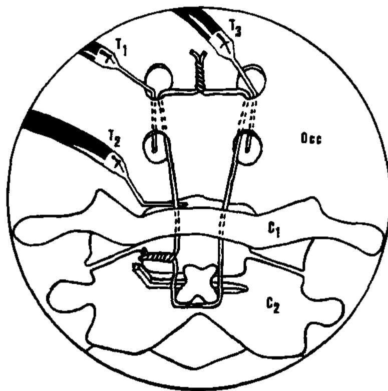

Figure 1. The position of the thermocouples (T1–T3). T1 positioned in the lower occipital burr hole and T2 positioned between foramen magnum and C1 on the cement side. T3 positioned in the lower occipital burr hole on the opposite side to the cement.

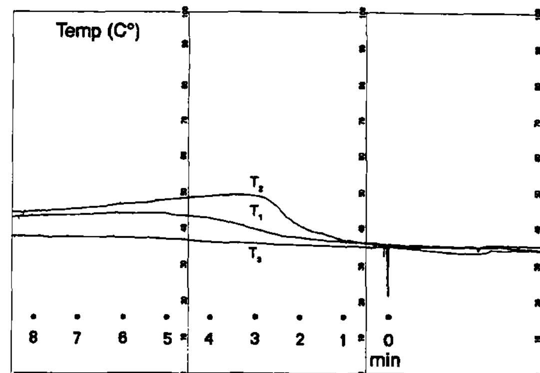

Figure 2. The epidural temperatures (T1–T3) in Case 5 obtained during continuous monitoring. Time 0 indicates encasement of the acrylic cement.

of medullary or cerebellar impairment. Cases 15 and 23 were reoperated for redislocation due to fracture of the spinous process of C2.

Results

The maximal temperature under the acrylic cement ranged from 30 to 69 °C, exceeding 47 °C for one minute in the majority of cases. The highest temperatures were recorded between the foramen magnum and C1. Irrigation did not have any influence on the recorded maximal temperatures under the acrylic cement (Table 1). The duration of temperature increase above 44 °C and 47 °C under the cement was not longer in the non-irrigated cases.

Discussion

The effect on nervous tissues of heat produced during the curing of acrylic cement in occipito-cervical fusion is not clear. Our study showed that in occipito-cervical fusion with the use of acrylic cement, the epidural temperature can increase to 69 °C, even if cooling with fluid is performed. The thermal damage to biological tissues is dependent upon time and this high temperature has been shown to cause permanent damage to cells after only a few seconds (Mortiz and Henriques 1947). The highest temperatures were recorded between the foramen magnum and C1, where the major body of the acrylic mass is located. The duration of the temperature increase was also longest in this location.

Yokota et al. (1982), without recording the actual temperature, noted changes on spinal-evoked potentials following application of acrylic cement over the spinal dura. After 30 minutes of spinal cord heating with radio waves in dogs, Uchiyama et al. (1989) showed histological lesions at a temperature above 45 °C and permanent spinal-evoked potential changes above 46 °C. The authors suggest that the highest tolerable temperature for the normal spinal cord for a 30-minute heating period is approximately 44 °C.

We conclude that the epidural temperatures induced by the exothermic heat reaction during the curing of the cement in occipito-cervical fusion can be high enough to be hazardous, and that surface irrigation does not seem to reduce this risk.

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